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(72)Inventor : SUGAWARA TAKESHI
KINOMOTO YASUO
YOSHIOKA TAKASHI
ISOBE KOICHI

(54) MANUFACTURE OF COMPOSITE SULFUR FREE-CUTTING STEEL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method about a method for preventing surface defect and improvement of machinability as to the method for manufacturing composite sulfur free-cutting steel from a middle cross-sectional bloom.

SOLUTION: This method is for manufacturing the composite sulfur free-cutting steel and, after taking the shape of the cast bloom as a square or a rectangle, continuously casting and cutting, blooming rolling is executed to the bloom for bar steel by 2-4 passes so that an elongation ratio becomes 1.6-2.8 and, after that, rolled into steel bars and wire rods. In the relation with the thickness of the cast bloom, after adjusting T.O in molten steel so as to satisfy the equation: $0.22D+68 \leq T.O \leq 0.22D+118$ (In the equation, the thickness of the cast bloom is expressed by Dmm and the concentration of total oxygen in the molten steel by T.O ppm.), and executing continuous casting, the bloom is cut, the blooming rolling is executed and, after that, the bloom is rolled into the steel bars and wire rods.

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CLAIMS

[Claim(s)]

[Claim 1] Both in quality and in quantity C<=0.15%, Si<=0.05%, aluminum<=0.003%, Mn:0.50–1.50%, P:0.020 – 0.100%, N:20–150 ppm, S:0.100 – 0.350%, It is the manufacture approach of the sulfur compound free cutting steel which makes a fundamental component T.O:100–250 ppm of all oxygen Pb:0–0.300%. The manufacture approach of the sulfur compound free cutting steel which carries out slabbing to the slab for bar steel with two to 4 pass so that this cast piece may be heated and a draw ratio may be set to 1.6–2.8, after carrying out continuous casting, using a cast piece configuration as a square or a rectangle and cutting to predetermined die length, and is characterized by rolling out from this slab to a steel bar or a wire rod after an appropriate time.

[Claim 2] Both in quality and in quantity C<=0.15%, Si<=0.05%, aluminum<=0.003%, Mn:0.50–1.50%, P:0.020 – 0.100%, N:20–150 ppm, S:0.100 – 0.350%, It is the manufacture approach of the sulfur compound free cutting steel which makes a fundamental component T.O:100–250 ppm of all oxygen Pb:0–0.300%. The manufacture approach of the sulfur compound free cutting steel which carries out slabbing of this cast piece, considers as the slab for bar steel, and is characterized by rolling out from this slab to a steel bar or a wire rod after an appropriate time after adjusting and carrying out continuous casting and cutting the T.O concentration in molten steel so that (1) type may be satisfied in relation with cast piece size.

0.22D+68 <= T.O <= 0.22D+118 A square or the thickness (mm) of a rectangle cast piece, and T.O of (1), however D are all the oxygen densities (ppm) of molten steel.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention offers the policy of the surface crack prevention approach in a steel bar or a wire rod product, and machinability improvement about the manufacture approach of the sulfur compound free cutting steel by interruption side bloom continuous casting.

[0002]

[Description of the Prior Art] Since machinability is excellent, the low charcoal S free cutting steel of SUM22 and AISI1213 grade and the low charcoal S-Pb free cutting steel of AISI12L14 grade are used for various cutting components, such as a nut for automobiles, a screw, and a precision machinery component, so much.

[0003] About the continuous casting process of these sulfur compound free cutting steels, some are reported conventionally. a ratio [in / as an example of a report about improvement in machinability. / in JP,62-207547,A and JP,62-207548,A / continuous casting] — the method of enlarging MnS to crystallize and improving machinability is described by by restricting amount of water or falling the cooling rate of a cast piece within a continuous caster.

[0004] The molten steel degree of superheat in tundish is made into 10 degrees C or more, and the method of controlling the cooling rate of a cast piece below to a predetermined value, and improving machinability is stated to JP,2-155548,A. Moreover, while regulating the chemical entity of C, Si, and others, the method of specifying the amount of oxide system inclusion 53 micrometers or more is stated to JP,7-173574,A.

[0005] As a report of the prevention approach of a surface crack, [%S] / [%C] / [%O] ratio is specified, for example to JP,59-19182,B, generating of a blowhole is suppressed, and the method of restricting Mn concentration, securing hot-working nature, and preventing a rolling crack is described.

[0006]

[Problem(s) to be Solved by the Invention] As slab for bar steel with which rolling of a steel bar, a wire rod, etc. is presented, although the size of 115mm angle – 180mm angle is generally used, as these materials, recently, many bloom billet cast pieces manufactured by the continuous casting process are used, and it is divided roughly into the small cross-section billet of the same size as the large cross-section bloom which has slab about 4 to 15 times the cross sectional area of for bar steel, or slab.

[0007] By the approach of manufacturing slab by slabbing from the large cross-section bloom, while the energy expenditure which heating rolling takes increases since cast piece size is large, heating time is as long as about 2 – 3 hours and the count of rolling pass also has it as about 10 – 20 times, there is a problem which a rolling yield falls and a manufacturing cost increases sharply. [much]

[0008] On the other hand, in the case of a small cross-section billet, since slabbing is omitted, it is advantageous in cost, but since it becomes that a sulfide, an oxide, etc. which were crystallized to the grain boundary in the coagulation process cause embrittlement, and a deep surface crack occurs at the time of rolling in order to roll out a billet with cast structure to a steel bar or a wire rod, or high-speed casting, the surfacing nature of oxide system inclusion is checked and there is a problem of machinability falling. It is the actual condition which is being manufactured about these reasons to the sulfur compound free cutting steel from the large cross-section bloom with a manufacturing cost higher than before.

[0009] As mentioned above, a technical problem occurs also in any of large cross-section bloom continuous casting and small cross-section billet continuous casting, and if the manufacture from the interruption side bloom which has a draw ratio in the range of 1-4 is attained, the above-mentioned trouble will improve radically.

[0010] The first technical problem in manufacture by the interruption side bloom of a sulfur compound free cutting steel is establishment of the surface crack prevention approach at the time of rolling out to a steel bar or a wire rod from the slab by which slabbing was carried out by the low draw ratio. The second technical problem is the improvement to the surfacing nature fall of the oxide system inclusion at the time of high-speed casting, and the improvement to the fall of the machinability by the miniaturization of MnS by increase of the cast piece cooling rate according to the formation of an interruption side to a list.

[0011]

[Means for Solving the Problem] Claim 1 of this invention offers the prevention approach of a surface crack. Both in quality and in quantity Namely, C<=0.15%, Si<=0.05%, aluminum<=0.003%, Mn: 0.50–1.50%, P:0.020 – 0.100%, N:20–150 ppm, It is the manufacture approach of the sulfur compound free cutting steel which makes a fundamental component T.O:100–250 ppm of all oxygen S:0.100 – 0.350%, and Pb:0–0.300%. After carrying out continuous casting, using a cast piece configuration as a square or a rectangle and cutting to predetermined die length, slabbing is

carried out to the slab for bar steel with two to 4 pass so that this cast piece may be heated and a draw ratio may be set to 1.6-2.8, and it rolls out from this slab to a steel bar or a wire rod after an appropriate time.

[0012] Next, claim 2 of this invention is concerned with the cure against improvement of machinability. Both in quality and in quantity. Namely, C<=0.15%, Si<=0.05%, aluminum<=0.003%, Mn: 0.50-1.50%, P:0.020 - 0.100%, N:20-150 ppm. It is the manufacture approach of the sulfur compound free cutting steel which makes a fundamental component T.O:100-250 ppm of all oxygen S:0.100 - 0.350%, and Pb:0-0.300%. After adjusting and carrying out continuous casting and cutting the T.O concentration in molten steel so that (1) type may be satisfied in relation with cast piece size, slabbing of this cast piece is carried out, and it considers as slab, and rolls out from this slab to a steel bar or a wire rod after an appropriate time.

[0013]

0.22D+68 <= T.O <= 0.22D+118 A square or the thickness (mm) of a rectangle cast piece, and T.O of (1), however D are all the oxygen densities (ppm) of molten steel.

[0014]

[Embodiment of the Invention] Although Pb is added for S 0 to 0.300% 0.100 to 0.350% as a machinability improvement element in the target sulfur compound free cutting steel by this invention, S crystallizes MnS granular at the time of coagulation, extends it with rolling, and becomes fusiform, and Pb is distributed to homogeneity as a Pb particle with a diameter of several micrometers in steel.

[0015] MnS and Pb are detailed elasticity inclusion, while becoming a source of internal stress concentration at the time of cutting and raising cutting ability, the lubrication action between a tool and scraps is raised, cutting force is made small, and there is effectiveness of raising scraps processability.

[0016] Furthermore, in the sulfur compound free cutting steel, since components other than S or Pb also affect machinability, the content is specified as follows. in order [namely,] C considers as 0.15% or less from extension of a tool life, to regulate them to 0.05% or less of each, and 0.003% or less in order that Si and aluminum may form a hard oxide and may speed up tool wear, to add Mn 0.50 to 1.50% so that it may increase more than stoichiometry with S in MnS, and for P and N to make steel dissolve and to raise machined surface granularity — respectively — 0.020 - 0.100% — and it is added by 20-150 ppm.

[0017] O in molten steel exists in the concentration which balances C, Mn, etc. as an oxide of MnO-SiO₂ system or others by the reaction of near, molten steel, and a refractories and a slag fundamentally, and the content is 100-250 ppm as all oxygen T.O.

[0018] First, the reason for specifying a draw ratio (a cast piece cross sectional area / slab cross sectional area) to 1.6-2.8 by this invention is explained below. In case the slab for bar steel of a sulfur compound free cutting steel is rolled out to a steel bar or a wire rod, in order to prevent generating of a surface check, it is necessary to remove the embrittlement factor by Pb inclusion in the sulfide crystallized to the grain boundary, and an oxide list.

[0019] However, since the draw ratio from a cast piece to slab is naturally small compared with the large cross-section bloom, in order to make crystal grain of slab detailed by slabbing and to remove an embrittlement factor, the interruption side bloom enlarges the rolling draft per one pass, makes rolling force fully permeate from the front face of a cast piece to a core, and needs to destroy cast structure.

[0020] It became clear that it is stabilized when according to investigation of artificers there is close relation to the austenite grain size of the draw ratio and the count of pass in slabbing, and the slab obtained, a draw ratio is made or more into 1.6 as shown in drawing 1, and 2 - 4 pass rolling is performed, and five or more detailed organizations were obtained.

[0021] When a draw ratio carries out 2-4 pass rolling less than by 1.6 so that clearly from drawing, or when the rolling draft per one pass is small and a draw ratio performs multi-pass rolling of 5 or more ****s 1.6 or more, it is stabilized and five or more are not obtained.

[0022] In five or more austenitic grain size numbers, in order that it may be destroyed, cast structure may make it detailed and a sulfide, an oxide, and Pb inclusion may carry out homogeneity distribution minutely, grain boundary embrittlement cannot take place and already becomes securable [hot-working nature equivalent to the slab which carried out slabbing] from the large cross-section bloom. From the above reason, by this invention, the draw ratio from a cast piece to slab is specified or more as 1.6, and 2-4 pass rolling is carried out.

[0023] Next, in such slab, although the size of the slab for bar steel has common 115mm angle - 180mm angle like the above-mentioned, if the example of representation of the cast piece size which can be rolled out with two to 4 pass is searched for, Table 1 will be obtained.

[0024] Here, while making the maximum reduction-of-area ratio per one pass and making 1.8 or less and the diameter of a roll of slabbing below into 1100mmphi for the axial ratio (proportion of the long side/shorter side of each pass) less than 30% as a prerequisite, the width-of-face flare by the draft was computed by having approximated it to one third of rolling drafts. When a reduction-of-area ratio and an axial ratio were larger than these values, whenever [angle-of-bite] became excessive, and since a slip was generated, or it became easy to generate the torsion and **** of slab and rolling workability fell, it considered as the upper limit.

[0025] From Table 1, the slab of 115mm angle is a two pass from the cast piece of 145mm angle of a draw ratio 1.6, and can be rolled out with four pass from 180mm angle cast piece of a draw ratio 2.4, respectively. Moreover, the slab of 180mm angle is a two pass from 240mm angle cast piece of a draw ratio 1.8, and can be rolled out with four pass from 300mm angle cast piece of a draw ratio 2.8, respectively. And if cast piece size exceeds 300mm angle (i.e., if a draw ratio exceeds 2.8), the reduction of area will exceed 30%, and shaping of an axial ratio will become impossible with four pass exceeding 1.8.

[0026] Since it stated above, in this invention, the draw ratio from a cast piece to slab is specified as 1.6–2.8, and two to 4 pass performs slabbing. In addition, the cast piece configuration is advantageous to the direction made into a square or a rectangle manufacturing slab by the count of pass smaller than a round shape etc.

[0027]

[Table 1]

铸片サイズ (mm)	压下量 (mm)	パス回数	減面率 (%)	軸比	延伸比	鋼片サイズ (mm)
145×145	45	2	24	1.6	1.6	115×115
240×240	91	2	30	1.8	1.8	180×180
180×180	49	4	26	1.7	2.4	115×115
300×300	90	4	30	1.8	2.8	180×180

[0028] In this invention, the reason for adjusting T.O in molten steel so that (1) type may be satisfied in relation with cast piece size is explained. In continuous casting, a casting rate (Vc) changes according to cast piece size, and it is so common that cast piece size is small to be drawn out at high speed.

[0029] For example, although based also on a continuous caster or an operating condition, the cast piece of Vc=1.5 – 2.0 m/min and 300mm angle is cast [the cast piece of 145mm angle] for the cast piece of Vc=2.0 – 3.0 m/min and 200mm angle in Vc=0.6 – 1.2 m/min.

[0030] SiO₂ and aluminum 2O₃ of an amount, and other hard oxides are contained in a sulfur compound free cutting steel a little which is mixed unescapable from refractories or a slag besides the MnO-SiO₂ system inclusion as deoxidation products, and it is harmful to it to machinability.

[0031] Since a casting rate becomes quick like the above-mentioned as cast piece size becomes small especially, the surfacing nature of inclusion is checked and machinability falls. From this viewpoint, artificers investigated [sizes / various / cast piece] with the slime extraction method about the relation between Tin molten steel.O, and the large-sized inclusion number in a cast piece.

[0032] According to the result, when the same, as for the inclusion number in a cast piece, the one where cast piece size is smaller has much Tin molten steel.O clearly. Therefore, in order to reduce the inclusion number, according to cast piece size, it is necessary to adjust Tin molten steel.O to the proper range within specification. The relation between the cast piece size which artificers measured, Tin molten steel.O, and machinability is shown in drawing 2.

[0033] The machined surface granularity (Rz) in the plunge cut of 80mmphi steel bar estimated machinability. (1) type will be obtained, if machined surface granularity asks for this range from a measurement result noting that less than 20 micrometers is a good region.

0.22D+68 <= T.O <= 0.22D+118 (1) — here, a square or the thickness (mm) of a rectangle cast piece, and T.O of D are all the oxygen densities (ppm) of molten steel.

[0034] In the field where T.O concentration is higher than the right-hand side of (1) type, Rz is set to 20 micrometers or more, and machinability serves as a defect, when there is too much oxide system inclusion. On the other hand, also when T.O concentration is lower than the left part of (1) type, Rz is set to 20 micrometers or more, and machinability serves as a defect.

[0035] As a result of investigating this reason, it turned out that it becomes easy for Tin molten steel.O to prolong MnS with rolling in being low, and machinability falls. And within limits specified by (1) formula, MnS also presents proper fusiform and there is also no bad influence of oxide system inclusion, and machinability is good and it is checking being realized about which cast piece size and casting rate.

[0036] An example of the operation gestalt of this invention is shown in drawing 3. 1 — a ladle and 2 — tundish and 3 — mold and 4 — a secondary-cooling-of-concrete band and 5 — a guide roll and 6 — a cutting machine and 7 — for a cogging mill and 10, as for a slab heating furnace and 12, slab and 11 are [a cast piece and 8 / a cast piece heating furnace and 9 / a looping mill and 13] wire rod coils.

[0037] It explains below per example of the operation gestalt of this invention according to claim 1. Using mold 3, after casting the bloom cast piece for sulfur compound free cutting steels of 145mm angle – 300mm angle and heating the cast piece 7 after cutting, a cross-section configuration fabricates to the slab 10 of 115mm angle – 180mm angle with two to 4 pass using a cogging mill 9, and manufactures the wire rod coil 13 of 7mmphi from this slab. The draw ratio from the cast piece in this case to slab is set to 1.6–2.8. About the wire rod obtained, surface quality level good as a sulfur compound free cutting steel is secured.

[0038] Next, with the operation gestalt of this invention according to claim 2, after adjusting Tin molten steel.O in a ladle 1 and tundish 2 so that (1) type may be satisfied according to cast piece thickness, and casting a cast piece 7, slabbing of this cast piece is carried out, and it considers as slab 10, and rolls out in the wire rod coil 13 from this slab after an appropriate time. Machinability and the quality of the material with the wire rod good as a sulfur compound free cutting steel obtained are secured.

[0039]

[Example] The example of this invention is explained below at a detail. After the chemical entity ingot the molten steel of P-0.285% [of 0.08% C-0.01% Si-1.05% Mn-0.075%] S-80ppmN-280ppmT.O with the 270t converter, (%CaO) in a slag, (%SiO₂), (%FeO), etc. were adjusted by ladle refinement (%MnO), and subsequently to the inside of the molten

steel in a ladle. Pb fine particles were blown by the injection method, and it adjusted to Pb 0.250%.

[0040] The molten steel degree of superheat (TD-SH) in tundish with the bloom continuous caster shown in drawing 3 for the interruption side bloom of 145mm angle - 300mm angle. Next, 20-40 degrees C, a secondary-cooling-of-concrete ratio, after setting amount of water to 0.41-/kg and casting at the casting rate according to each cast piece size. It fabricated with HV type cogging mill of 700mm [of diameters of a roll] phi-900mmphi to the slab of 115mm angle - 180mm angle with 2 - 4 pass rolling after about 1-hour heating so that this cast piece might be cut to predetermined die length and the cross-section mean temperature might become 1100-1150 degrees C with a cast piece heating furnace.

[0041] As an example of this invention according to claim 1, cast piece size, slabbing conditions, and the surface crack results of a wire rod are shown in Table 2 with the example of a comparison. In addition, surface crack results evaluated by performing score attachment according to the depth and die length in 7.0mmphi wire rod.

[0042] First, the cast piece of 145mm angle was fabricated by 45mm of rolling drafts, the 24% of the maximum reduction of area, the axial ratio 1.6, and draw ratio 1.6 per one pass to the slab of 115mm angle with two pass rolling. Moreover, from the cast piece of 300mm angle, it fabricated by 90mm of rolling drafts, the 30% of the maximum reduction of area, the axial ratio 1.8, and draw ratio 2.8 per one pass to the slab of 180mm angle with 4 pass rolling.

[0043] Similarly, from the cast piece of the square between 145mm angle - 300mm angles, or a rectangle, the slab of 115mm angle, 150mm angle, or 180mm angle was fabricated by the two pass, three pass, or 4 pass rolling so that it might become a count of the minimum pass in the range of the 30% or less of the maximum reduction of area, 1.8 or less axial ratio, and draw ratios 1.6-2.8.

[0044] Here, as a configuration of the bloom cast piece for bar line material, 1.7 or less rectangle has a square or a common flat ratio (proportion of a long side pair shorter side), and the flat ratio of a rectangle cast piece is set to about 1.5-1.6 in the example of this invention.

[0045] Here, although it was also possible to have rolled out the slab of 115mm angle by the two pass from the cast piece of under 145mm angle, since a draw ratio became less than 1.6 in this case and detailed-ization (with an austenitic grain size numbers of five or more reservation) of cast structure was not able to be performed, 145mm angle was made into the minimum of cast piece size.

[0046] Moreover, in rolling out the slab of 180mm angle from the cast piece of 300mm ****, in order that the maximum reduction of area in 4 pass rolling might exceed 30% and an axial ratio might exceed 1.8, 300mm angle was made into the upper limit of cast piece size. The surface crack score of a wire rod is as good as 0-1, and it is fully satisfied with the example which becomes this invention of the quality level as a sulfur compound free cutting steel so that clearly from Table 2.

[0047] On the other hand, when it fabricated from the cast piece of 130mm angle to the slab of 115mm angle with two pass rolling in the example of a comparison, it fabricated from the cast piece of 210mm angle to the slab of 180mm angle with 4 pass rolling, and a case and also when it omitted slabbing from the cast piece of 150mm angle and direct radiation material rolling was performed, since a draw ratio was all less than 1.6, the surface crack occurred in the wire rod.

[0048] Moreover, although the surface crack score in a wire rod was as good as 1 when it usually fabricated from the 400mmx600mm large cross-section bloom to the slab of 165mm angle by the cogging method, for a certain reason, about 3 hours and slabbing took 25 pass to the draw ratio also for 8.8 at cast piece heating, and the manufacturing cost in connection with slabbing increased sharply.

[0049]

[Table 2]

銘 錠 片 サ イ ズ (mm)	分塊圧延条件							線材の 表面疵 評点
	錠 片 加 熱 時 間 (H)	ロ ル 径 (mmφ)	圧 下 量 (mm)	ペ ス 回 数	減 面 率 (%)	軸 比	延 伸 比	
本 發 明	145×145	1.0	700	45	24	1.6	1.6	115×115 1
	200×200	1.0	700	76	30	1.8	1.8	150×150 0
	240×240	1.0	700	91	30	1.8	1.8	180×180 1
	131×195	1.0	700	48	25	1.7	1.9	115×115 1
	175×277	1.0	700	76	30	1.8	2.2	150×150 0
	210×332	1.0	700	91	30	1.8	2.2	180×180 0
比 較 例	180×180	1.0	900	49	26	1.7	2.4	115×115 0
	240×240	1.0	900	68	27	1.7	2.6	150×150 0
	300×300	1.0	900	90	30	1.8	2.8	180×180 0
	130×130	1.0	700	23	13	1.3	1.3	115×115 5
	210×210	1.0	900	22	4	1.2	1.4	180×180 4
	150×150	0	-	0	0	-	1.0	150×150 7
	400×600	3.0	1100	≤150	25	≤30.0	≤1.8 8.8	165×165 1

[0050] As an example of this invention according to claim 2, the results of an investigation of the slime extract inclusion number 53 micrometers or more in Tin cast piece size and molten steel O, casting conditions, and the obtained cast piece and machinability are shown in Table 3 with the example of a comparison.

[0051] Tin molten steel O from generally it being known that it is closely related to whenever [basicity (%SiO₂)// in a pan top slag / (%CaO) or oxidation] (%FeO+MnO) In this example, it adjusted to the amount of pan top slags (%CaO), and each T.O value according to the cast piece thickness specified by (1) formula by measuring (%SiO₂), adding calcined lime etc. on a pan if needed, and controlling basicity and whenever [oxidation].

[0052] In addition, machinability performed the plunge cut about 80mmphi steel bar rolled out from the obtained slab, and evaluated it by the machined surface granularity Rz (JIS). Plunge cut conditions are shown below.

** Test specimen : 80mmphi steel bar, ** tool:SKH57, ** cutting speed:80 m/min** feed-rate:0.05 mm/rev, **2sec cutting / 5sec un-cutting [0053]

[Table 3]

	铸片サイズ (mm)	溶鋼中T.O (ppm)	TD-SII (°C)	Vc (m/min)	铸片介在物 個数(個/Kg)	被削性Rz (μm)
本 発 明	145×145	125±25	20~40	2.65	41	15
	175×277	132±25	20~40	2.15	36	15
	200×200	137±25	20~40	1.90	32	16
	210×332	139±25	20~40	1.75	35	14
	240×240	146±25	20~40	1.50	27	13
	300×300	159±25	20~40	1.05	38	14
比 較 例	400×600	181±25	20~40	0.60	40	15
	145×145	180±25	20~40	2.65	265	39
	300×300	180±25	20~40	1.05	61	25
	145×145	70±25	20~40	2.65	27	34
	300×300	100±25	20~40	1.05	28	28

[0054] Now, there is little inclusion number 53 micrometers or more by which the slime extract was carried out by the approach of becoming this invention also in the case of which cast piece size or a casting rate in less than 50 pieces/[kg and] so that clearly from Table 3, less than 20 micrometers is attained and machined surface granularity (Rz) of machinability is good.

[0055] On the other hand, when the bloom of 145mm angle or 300mm angle was cast as T.O180ppm among molten steel as an example of a comparison, since the cast piece inclusion number exceeded kg in 50 pieces /, machined surface granularity exceeded 20 micrometers and machinability was poor.

[0056] Moreover, in the example of a comparison which adjusted the bloom of 145mm angle and 300mm angle to T.O70ppm and 100 ppm among molten steel, respectively, and cast it, although the cast piece inclusion number decreased sharply, since T.O was too low as mentioned above, MnS extended with rolling, machined surface granularity exceeded 20 micrometers similarly, and machinability fell.

[0057]

[Effect of the Invention] This invention can prevent beforehand generating of the surface crack in a steel bar or a wire rod while it fabricates slab with 2 – 4 pass rolling from the interruption side bloom and aims at drastic reduction of cogging cost by this. Moreover, by adjusting Tin molten steel O proper according to cast piece thickness, manufacture of the sulfur compound free cutting steel excellent in machinability is enabled, and such industrial application effectiveness is very large.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Drawing showing the relation of the austenite grain size of a draw ratio, the count of pass, and slab

[Drawing 2] Drawing showing the relation of cast piece thickness, and Tin molten steel.O and machinability

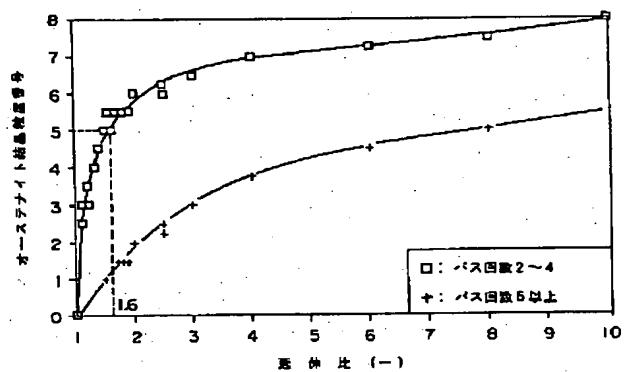
[Drawing 3] Drawing showing an example of an operation gestalt

[Description of Notations]

1 [... A secondary-cooling-of-concrete band, 5 / ... A guide roll, 6 / ... A cutting machine, 7 / ... A cast piece, 8 / ... A cast piece heating furnace, 9 / ... A cogging mill, 10 / ... Slab, 11 / ... A slab heating furnace, 12 / ... A looping mill, 13 / ... Wire rod coil] ... A ladle, 2 ... Tundish, 3 ... Mold, 4

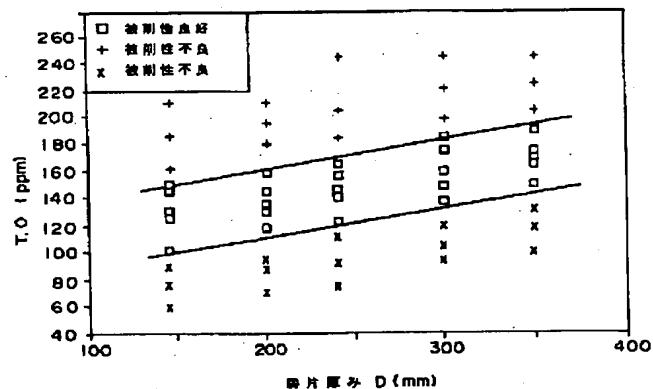
[Translation done.]

Drawing selection drawing 1



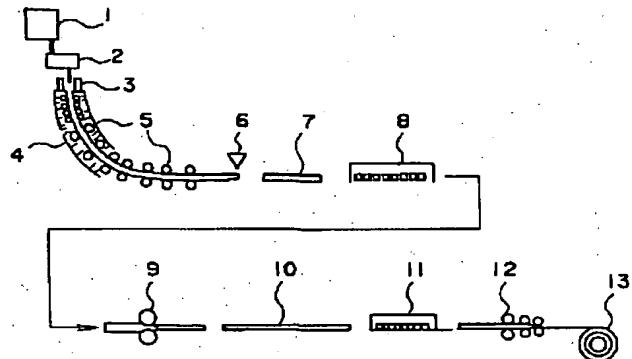
[Translation done.]

Drawing selection drawing 2



[Translation done.]

Drawing selection drawing 3



[Translation done.]